United States Department of Agriculture,
OFFICE OF EXPERIMENT STATIONS—Circular No. 53.
A. C. True, Director.

REPORT OF THE COMMITTEE ON RURAL ENGINEERING OF THE ASSOCIATION OF AMERICAN AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS.

[This report was presented to the Association of American Agricultural Colleges and Experiment Stations at the convention held in Washington, D. C., November 17–19, 1903, and the recommendations of the committee were indorsed by the Association.]

At the last meeting of the Association of Agricultural Colleges and Experiment Stations the following resolution was adopted:

Whereas, The agricultural colleges and experiment stations, as well as the U. S. Department of Agriculture, are broadening their work relating to irrigation and farm machinery, and other lines of agricultural engineering, and there is pressing need of the more definite formation of plans for this work: Therefore be it

Resolved, That this Association make provision for the appointment of a standing committee on agricultural engineering to consist of five members, and that it be made the duty of this committee to cooperate with the Department of Agriculture in promoting education and research along the different lines of agricultural engineering.

Your committee, appointed in pursuance of this resolution, begs leave to submit the following progress report:

Rural engineering, as defined in Circular 45 of the Office of Experiment Stations, is "the science and art of laying out farms, designing and constructing farm buildings and works, and making and using farm implements and machinery."

A careful examination of existing conditions in the United States leads to a belief that there should be a strengthening of the courses of instruction in these subjects in our colleges, and the inauguration of comprehensive investigations and research work to ascertain the best practice in this and other lands and provide up-to-date information for instruction in our institutions of learning. This is equally true, whether the opportunities for students or the needs of the American farmers are considered. The field of practical usefulness for the one and the need of the other are alike extensive. In support of these conclusions we submit the following facts:

The comparatively large areas of American farms makes the laying out and arrangement of the different fields a matter of especial importance to our farmers. In order to maintain the fertility of the soil, rotation of crops must be practiced. To do this fields should have such areas and such number as will make a regular system of rotation

feasible. This gives an opportunity for the exercise of skill and intelligence, and, in connection with the building of roads leading from farm buildings to different parts of the farm, may involve marked economy or serious waste in the expenses of construction and in the distances traveled in going to and from the fields. It is, therefore, one of the things to which attention should be directed in our institutions of learning.

Closely related to the arrangement of fields is the construction and grouping of farm houses and farm buildings, not only to secure efficiency and economy, but to contribute to the healthfulness and attractiveness of farm life. There is no doubt that present conditions in these particulars in the United States are inferior to those in most European countries, and it is equally certain that improving the conditions of farm life will have much to do with determining whether the exodus of people from the country to the cities will be checked or become greater in the future than in the past.

In the construction of farm buildings, both barns and houses, the farmer is almost entirely dependent on his own knowledge and ingenuity in preparing plans and often in their execution. The designing of city buildings is largely in the hands of architects and engineers, and they are constructed by expert mechanics. They have, therefore, a finish and convenience which add largely to the attractiveness of city life. In the country, however, exactly the reverse is true. The great majority of farm buildings are unsatisfactory, whether considered from the standpoint of appearance, durability, adaptability to the work to be done, healthfulness, or pleasantness for the occupants. Some problems in connection with farm buildings need careful study. Among these is ventilation. The fact is we do not know either the effect of poor ventilation or the most efficient means of securing good ventilation. But the majority of the improvements to be wrought do not require research so much as the application of skill and ingenuity in design. One illustration of this is the fact that nothing is of more service in a home than a convenient water system. Much of the dislike which many women have to farm life comes, consciously or unconsciously, from the heavy work of handling water in cooking and washing, all of which could be easily saved by the adoption of readily available means. There is no reason why a farm house should not be as attractive as a city house, and there is no reason why the grounds surrounding farm houses should not be made as attractive as city parks. It is largely because farm life and the farm home are not attractive that many of the enterprising, aggressive youth of the country flock to the cities.

Heretofore nearly all farm buildings have been built of wood. A change in this direction is inevitable in the near future. Timber is becoming scarce and costly and must be supplemented by brick, stone,

or concrete. We ought to begin in the near future to determine the relative value and cost of these different materials, and this is particularly a work for the colleges and stations. The character of farm buildings has also changed greatly in the past quarter of a century. Formerly they were simply storage places for grain or shelters for live stock. With the introduction of feed cutters, silos, power churns, centrifugal cream separators, and scores of other machines formerly unknown these buildings are becoming as complex in their designs and uses as factories, and there is need of scientific study to determine the most economical designs to fulfill these different requirements.

Another reason for strengthening these courses of study is the fact that all of the public lands susceptible of cultivation in their natural condition have been taken up, so that this outlet for our growing population is closed. We have, however, large areas of land which, when drained or irrigated, can be settled upon and cultivated. The importance of irrigation is manifest from the statement that in two-fifths of the United States it is an absolute necessity to the existence of civilized life, and there is every reason to believe that it is destined to be an important means of increasing production throughout the whole country. But in order that fields may be irrigated they must be smoothed so that water will flow over them; and in order that the best results may be obtained the methods of applying water to crops to secure the greatest economy in use and the largest yields must be studied, and the mutual relation of peoples who depend on the same water supply must be ascertained in order that we may have institutions which will secure harmony and justice.

An excellent beginning in the study of these questions has been made in a few institutions and by the Office of Experiment Stations, but there is a great field for the extension of both instruction and research and for a broader cooperation between the Department and the State institutions in both the cultural and engineering sides of this branch of agriculture.

Of wider application and scarcely less importance is the subject of drainage. The marsh and overflowed lands along our seacoast and the bottom lands bordering many of our rivers are at present unsightly, unproductive, and in some instances a menace to the health of surrounding districts. They need only to be diked and drained to be the most valuable lands in the country. The carrying out of these improvements will add immensely to the agricultural values of the country, and the work is certain to be undertaken in the near future. It involves, however, a larger knowledge of agricultural engineering than can now be obtained in our land-grant colleges. In fact, the profession of agricultural engineer, so prominent in Europe, is almost unknown in this country. Very little has been done in this country to develop a satisfactory drainage practice. The principles of drainage are understood

by but few, and instruction in our colleges is meager and far from being up-to-date. Drainage laws are far from satisfactory and need to be modified because this work is beyond the means of individuals and must be carried out by organizations of large numbers of landowners associated under some definite legal plan. Careful work must be done in the study of the practical side of this subject, in determining the most effective methods of constructing ditches, in determining the kind of underdrains to be used, the depth at which they should be laid, the distance apart, etc.

We believe that in irrigation and drainage there is a field for cooperation between the Department of Agriculture and the experiment stations and colleges which ought to be more fully utilized, the Department of Agriculture coordinating the work of the stations and aiding them in carrying out original researches.

Associated with drainage and irrigation is another branch of hydraulic agriculture whose importance has not been properly realized. This is the terracing and draining of hillside farms in order to protect them from the destructive effects of erosion. It is an unfortunate fact that much of the activity of the last century in subduing and settling this country has been of a destructive character. Forests have been cut from the headwaters of streams; the hillsides which they protect have been exposed to the erosion of storms, and the evils of the work done by rainfall have been aggravated by the planting of these lands to crops which require clean culture, such as corn, tobacco, and cotton, which provide no binding material for the soil. As a result, much of the accumulated fertility has been carried down into the channels of streams, thus leaving thousands of acres of what was fertile land not many years ago scarred with gullies and practically abandoned to weeds and brush. We must stop this destructive style of farming if we are to maintain the prosperity and provide an adequate food supply for many sections in the eastern half of the United States. To find out how best to do this and to encourage farmers to begin action is a work which both the Department of Agriculture and the different State experiment stations should take up at once. The hill lands of France, Germany, and England are as fertile as they were a century ago, although many of them are devoted to cultivated crops. The credit for these results is due to the existence of a body of trained agricultural engineers, a class of professional men not now existing in the United States. The time has come when our colleges should lend themselves actively to this sort of training. The opportunities for employment in irrigation, drainage, and hillside protection are sufficiently great to make it an attractive course to young men having aptitude for such work, and it is the field to which we must look for the largest results in the extension of our productive area and in the conservation of the fertility of much of the land now being farmed.

Another branch of rural engineering is the construction of country roads. Increase in population in our cities has resulted in larger areas being devoted to the production of perishable products—such as milk, garden truck, and fruit. The marketing of these has greatly increased the travel on country roads. The character of these products is such as to demand quick transportation, thus rendering it necessary that the roads should be hard and smooth, and this is being emphasized by the fact that the automobile and traction engine require a better roadway than the horse and cart. To build roads suited to the conditions of modern life, especially in the vicinity of cities, requires a knowledge of engineering wholly different from that of a quarter of a century ago and demands not only that the courses of instruction be strengthened, but that facilities be provided for experimentation regarding the best materials to use.

It is believed, however, that the greatest opportunities for students and for the improvement of the general agricultural practice of this country will be found in the systematic study of the manufacture and use of agricultural machinery. This country is the greatest maker and user of farm machinery in the world, and it is due largely to this fact that we have become the most prosperous agricultural country in the world. It has enabled the farmer to pay the high prices for labor created by the competition of our manufactories and has taken away from farm life much of the drudgery of manual toil and made it in the best sense an intellectual pursuit. Improvements in machinery have brought about a steady reduction in the cost of production, notwithstanding the steady rise in wages. The self-binder enables one man to accomplish the work done by four men with the best machinery in use at the close of the Civil War. The check-row corn planter and the two-horse cultivator have, according to a recent writer, lessened by more than half the labor cost of producing a bushel of Indian corn. Machinery has enabled the Eastern farmer to adopt intensive farming. The windmill pumps the water used in the dairy, the centrifugal separator skims the milk, and water or wind power runs the churn. The gasoline or steam motor is beginning to haul the product of the truck farm to the city market, rendering the farmer equally independent of horses and railways.

In the same way it has enabled the Western farmer to plant and harvest large areas, nothwithstanding the scanty labor supply to be found there. Last year a traction engine in California cut and thrashed over a hundred acres of wheat in a single day, doing the work of nearly one hundred horses with modern mowing and reaping machinery, and equaling the result accomplished by that many men and horses 50 years ago. Less than a century separates the operation of machines like this and the cutting of grain with the scythe and thrashing it with the flail, and the improvements which have been made in harvesting

machinery have been duplicated in many other lines of farm work. There are now traction engines which plow thirty acres of ground in a day. Recently a gasoline motor has been invented which promises to be as successful in displacing the horse in certain lines of work on the farm as the automobile is on the country roads.

The demands which these changes are making on the farmer for a knowledge of the principles of mechanics and for a certain amount of skill in their application is so much greater than it was a century ago that it can not be stated as a percentage. The question we have to consider is whether we have recognized this change in the courses of instruction in our agricultural colleges. Your committee is unanimously of the opinion that we have not, and that the facilities for instruction are not in keeping with the importance of this branch of agriculture. In the majority of institutions the same kind of mechanical training is given agricultural students as to students who expect to work in factories, while the work to be done by the farmer in the use of machines and tools is of a radically different character. On the farm one man must do many kinds of work and hence must use many different kinds of tools; in shops and factories one man does one thing or a few things only. This highly developed specialization produces efficient labor. A man uses a tool until he understands it thoroughly, recognizes immediately any defect, acquires a feeling of ownership in it, gives it constant care, and is often able to make improvements in its construction. All this is very different in the experience of the farmer. He uses one machine only a short time and then must take up another. What is learned about the construction and use of a machine at one time is largely lost before it is again called into use. The result of all this is that the farmer fails to develop that interest and mechanical sense which are necessary to the highest efficiency in the operation of the complex machinery which now forms a part of the equipment of every modern farm.

The records of the last census show that over one hundred million dollars worth of farm machinery is made and sold each year. The saving which would come to the people of this country by extending the life of each machine one year would be an immense addition to the annual profits of our farmers. This saving can be more than realized and it can be augmented by the greater efficiency which would come from expert care and management. At present it is notorious that the American farmer, with all his mechanical aptitude and inventive skill, is behind the other leading agricultural countries in his management and care of agricultural machinery. It is believed that this is largely due to the neglect of this subject in our schools. In Germany, France, and more recently in England, a well-equipped laboratory for testing agricultural machines and a museum filled with samples of machines of different patterns for examination by students is held to be as essen-

tial to proper instruction as a chemical laboratory. The first floor of the agricultural high school at Berlin contains a museum in which are found the best types of agricultural implements of the United States, England, and Germany. The student who makes proper use of that museum has a better understanding of the principles which govern the construction of the tools he is to use and the modifications to conform to different uses than it would be possible for him to acquire in any other way, and it is a kind of training especially demanded by the conditions of American farm life.

This training in the agricultural institutions of Germany is regarded there as of the highest value not only by farmers but by manufacturers. It gives them trained workmen in their shops; it gives them trained agents to extend their export trade in different countries. The union of agricultural and mechanical knowledge in their employees and agents has enabled German implement makers to greatly increase their export trade, and it is believed that the same result would follow similar training here. If we are to maintain our standing as a producing and manufacturing nation we must maintain our superiority as designers and users of farm machinery, and this can be best promoted by bringing the trained intelligence of the experts of the Department of Agriculture and of the students and professors of our agricultural colleges to bear on this problem. A few colleges have created departments for instruction in certain branches of rural engineering, the departments of irrigation engineering in Colorado and California being illustrations of this, and a number of colleges are now considering the establishment of courses in rural engineering with farm mechanics as the leading feature, and there is much interest in the development of these courses as independent lines of work. Among these are the colleges of agriculture in Illinois, Wisconsin, Minnesota, Iowa, and North Dakota. In each case this work has been inaugurated as a branch of instruction in agronomy. While this may answer as a beginning, the importance of the allied branches of rural engineering taken together entitles it to be made an independent department of instruction, having equal rank with agronomy or animal industry as they have been established in a number of institutions. The scheme outlined in the fifth report of the committee on methods of teaching agriculture, and published in Circular 45 of the Office of Experiment Stations, brings together in a logical way the scattered instruction which bears on this branch of agriculture and furnishes a systematic and well-rounded course. Such departments are needed to furnish opportunities for specialization by students who wish to prepare themselves for leadership along these lines of work, and would furnish a field for experimentation and systematic training for farmers in the subjects which to-day constitute the most important factors in the expenses and profits of American agriculture.

The same policy should be followed in the organization of the work

of the Department of Agriculture. This Department is now doing important and useful work in a number of branches of rural engineering, but its influence on the development of the country and the effectiveness of the investigators would be greatly promoted if all of these related lines of work were gathered together in one division, instead of being made simply incidents of the work of several bureaus organized to do other things, as is now the case. It is believed that the importance of these subjects warrants the adoption of this plan at an early date. One of the reasons for believing this is the consideration given to these subjects in other countries where their importance is far less than with us. The bureau of hydraulic agriculture is one of the leading bureaus of the agricultural department of France. It includes only drainage and irrigation. The relative importance of these subjects in France and this country is shown by the fact that France has only 400,000 acres of irrigated land, while we have nearly 8,000,000 acres irrigated and the work is still in its infancy. In France irrigation is not a necessity—only an aid to agriculture. In two-fifths of the United States it is a necessity for civilized life. Furthermore, the conditions which have been created in this country by the character of our irrigation development give to the irrigation investigations of the Department of Agriculture a significance and importance not possessed by similar work in any other country in the world.

Over 8,000,000 acres of sagebrush desert land has been reclaimed by the unaided efforts of farmers, without any assistance from either the Federal Government or the States, in such a manner as to produce good crops. This task is one of the greatest achievements of the agricultural classes of this or any other continent. It has involved an amount of experimenting and a waste of money in failures and partial failures which is inconceivable to those not practically familiar with western conditions. This task, however, has not been completed. Some of the most difficult problems yet remain to be solved. Some of the things which remain to be done are to determine the amount of water which each farmer should receive, and to provide for an equitable distribution of the waters of streams. The uncertainty regarding rights to water is one of the grievous evils which confront western farmers. It is believed that if these rights were so well established and protected that each farmer could know certainly that in times of scarcity he would receive his proper share, the value of each one of these 8,000,000 acres would be increased on an average at least $5, or an aggregate of $40,000,000 in all. But this is only one feature of the gain. Such a change will put an end to litigation and to the enormous expenditure of time and money which it involves.

The watering of 8,000,000 acres of land involves the handling of an enormous quantity of water each year. If this water could be transferred from the streams to the field with the same system and skill that

is exercised in the operation of some of our railroads, or that is shown in the distribution of water in some of the best districts of Italy and France, the gain in the saving of water and in the increased production of crops would be something enormous. At present in many parts of the West there is either a very defective system or no system at all, and a competent investigator has estimated that we are losing each year at least $10,000,000 on account of the faulty distribution of appropriated waters. These figures are sufficient to show the necessity for a systematic study of these questions by the Department of Agriculture and to show also why, with the increase in the cultivated area which is each year going on, the necessity for these investigations and their importance to the whole country is destined to increase.

There is no country where drainage problems are as important as in the United States. The swamp and overflowed lands of this country if reclaimed will equal in productive capacity practically the whole of France, yet the problems of drainage and diking, on which their successful reclamation depends, have as yet received but little study, and the practice in both directions is susceptible of great improvement.

The construction of country roads is an essential feature of rural engineering. The great extent of our country, its recent settlement, and the necessity for extensive improvements in those directions make it an important factor in the work of the Department of Agriculture. The necessity for improvements in roads has been referred to above, but the study of the character of these improvements involves also a study of the kind of machines and vehicles that are to travel on them. Along with the study of road making should go a study of the limitations and requirements of traction engines, automobiles, and all of the new forms of transportation which are becoming an essential factor of American farm life. The relation of the problems of farm machinery to irrigation and drainage has already been shown by the necessity of including in these investigations a study of the applications of power to pumping, because pumping is the only means of supplying water for irrigation in certain districts and an essential means of removing water from over-irrigated lands in others. The study of pumping has, of necessity, led to a study of the relative economy and effectiveness of different forms of power for the operation of pumps. There is equal need of similar studies of the applications of the different forms of power, whether steam, gasoline, electricity, water, or wind power in the other branches of farm work, and these are being brought home each year with increasing force to both the manufacturers and users of farm machinery. We believe, therefore, that all these related lines of work should be brought together in the Department of Agriculture in a single bureau, exactly as all the related lines of instruction in these subjects should be brought together in one distinct course in our colleges.

The necessity for increased attention to those subjects has been recog-

nized by both the Secretary of Agriculture and the Director of the Office of Experiment Stations. Dr. True has recommended that the name "irrigation investigations" be changed to "irrigation and agricultural engineering" in order to more correctly indicate the nature of the work being done, and the Secretary of Agriculture, on the recommendation of Dr. True, has included in his estimates to Congress a request for this change and for an increased appropriation to be expended in making investigations in the applications of power to farm machinery, the direction of these inquiries, as indicated in Dr. True's report, to be:

(1) Preliminary work in the collection and publication of information regarding the evolution, character, and uses of farm implements and machinery in this and other countries. This is important because the available literature on the subject is scattered, fragmentary, and out of date. A small beginning has just been made in this direction in a bulletin on The Evolution of Reaping Machines, recently published by this Office, and another bulletin describing corn-harvesting machinery, which is being prepared.

(2) Laboratory and practical tests, involving a study of principles of construction and methods of operation of farm implements and machinery with special reference to efficiency and economy. These might very properly include certain strictly technical inquiries regarding the fundamental nature of the various mechanical farm operations with a view to suggesting the best means of performing them with the implements and machines at present available, or with others, the construction of which will be indicated by the results of the inquiries. Such inquiries would require considerable laboratory equipment, but the results obtained would be useful to the farmer by securing for him the most efficient implement or machine for performing the desired operation, and to the manufacturer by assisting him in the construction of the desired implements and machines.

This committee recommends that the association declare itself in favor of the creation of separate departments of rural engineering in the colleges, that it give its hearty support to the efforts of the Secretary of Agriculture to extend the work of his Department along these lines, and that the executive committee be instructed to urge upon Congress the importance of giving the Department liberal appropriations for these purposes.

W. E. Stone,
A. R. Whitson,
Samuel Fortier,
C. F. Curtiss,
Elwood Mead,
Committee.

Recommended for publication.

A. C. True, *Director.*

Publication authorized.

James Wilson,
Secretary of Agriculture.

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